Washington State Department of Transportation

Memorandum

January 24, 2008

TO: Karen Zirkle
CED Coordinator

FROM: Kevin Lautz P.E. (360-705-7472)
Hydrologist, Watershed Program (HQ-ESO)

SUBJECT: Site & Reach Assessment / Evaluation of Treatment Alternatives
SR 8 MP 15.33 (Kennedy Creek) CED Site

The attached technical memorandum presents the site and reach assessment and evaluation of treatment alternatives for the above-reference chronic environmental deficiency (CED) site. This site is identified as a CED site based on the need for annual removal of accumulated sediment which obstructs the culvert, resulting in reduced fish passability as well as occasional water over the roadway.

Identified site-based factors include:

- constriction of the channel at the entrances to the CED culvert and the county culvert immediately upstream,
- presence of a 90 degree bend immediately below the CED culvert, and
- location of the county and CED culverts at or below a natural gradient break (higher to lower), where sediment deposition would normally be expected to occur.

An identified reach-based factor is the high to extremely high rate of sediment transport to the CED site due to mass wasting in the watershed above the CED site.

Three treatment alternatives were identified to redress one or more of the site-based factors identified above. None of the alternatives proposed will redress the identified reach-based factor (high sediment supply), but these alternatives should accommodate the factor to some degree. For this evaluation, it is assumed that the county culvert remains in place.

The recommended treatment alternative is to replace the existing culvert with a larger concrete box or ConSpan-type structure, skewing the alignment 25-35 degrees west relative to the existing alignment. The new culvert width will meet stream simulation criteria; it is estimated that the road bed will need to be raised a minimum of four feet. Below the realigned culvert, the construction of approximately 100-150 feet of channel will be needed, and the existing channel between the culvert outlet and the new channel will be abandoned. This alternative is recommended because it addresses all of the site-based factors and does not require substantial acquisition of new right-of-way.

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Attachment: Technical Memorandum

cc: Dick Gersib, WSDOT-ESO Watershed Program Manager

Site & Reach Assessment and Evaluation of Treatment Alternatives SR 8 MP 15.33 (Kennedy Creek) CED Site

Introduction

This report presents a site and reach assessment for the SR 8 MP 15.33 culvert crossing of Kennedy Creek (Figures 1 and 2). This is identified as a chronic environmental deficiency site based on the need for annual removal of accumulated sediment which obstructs the culvert, resulting in reduced fish passability and occasional water over the roadway.

Site Assessment

Culvert Design and Site History

This culvert is a 140 foot long, six foot (span) by four foot (rise) concrete box culvert with flared wingwalls (Figure 3). This culvert was installed at the time SR 8 was built (around 1960). Culvert gradient is 2.3 percent. The culvert shows wear from age and recurrent sediment abrasion; structural soundness of the culvert is unknown. There is a similar six foot by four foot concrete box culvert (gradient unknown) owned by Thurston County 85 feet upstream.

Sediment deposition to within six to 12 inches of the culvert soffit occurs one or more times per winter. Excess sediment is excavated as required by WSDOT maintenance crews under the general HPA for culvert maintenance. Because this general HPA limits excavation quantity to 50 cubic yards per occurrence, sediment is removed only from the culvert inlet and outlet. Accumulated sediment within the culvert remains, unless incidentally flushed out by natural flow.

The culvert has been identified as a fish passage barrier by WDFW (Site ID 997201) and is rated as 67 percent passable. Resident trout were the only fish identified by WDFW as potentially using habitat upstream of the culvert.

On December 3, 2007, a debris torrent originating in the upper part of the watershed (Figure 1) delivered large quantities of sediment (ranging in size from silt and sand to boulders) and woody debris to the site (Figure 4). Observers reported the wall of debris to be “100 feet wide and 15 feet high” (Ranch House BBQ website – www.ranchhousebbq.net) as it collided with the county culvert immediately upstream from the site and heavily damaged the adjacent Ranch House Barbeque restaurant. Runout of the debris onto SR 8 appears to substantiate the size and destructive power of the torrent. Obstruction of the county culvert and a portion of the channel upstream resulted in diversion of most of the flow over the county road and eastbound lanes of SR 8 and into the median, where it was conveyed to the next several culverts to the west. The CED culvert was almost completely filled with sediment, and mud and debris (including booths from the restaurant dining room) littered both eastbound and westbound lanes of SR 8, necessitating a two-day road closure. While sediment obstructing the inlet and the outlet of the CED culvert was excavated by WSDOT maintenance crews, there is currently (as of the date of this memo) a partial obstruction within the culvert, which requires most of the flow to continue to be diverted to the west.

One other incident of roadway inundation at this site is known to have occurred in 1996. That occurrence was associated with partial obstruction of the culvert and high flows occurring during a large storm event in January of that year.

Channel Conditions Upstream and Downstream of the Culvert

Both the county and CED culverts are located along a gradient break as the creek emerges from the Black Hills onto the valley floor (Figure 5). Channel gradient decreases from 4.8 percent to 2.5 percent at 570 feet above the county culvert inlet and then to 0.6 percent at a point 90 feet above the inlet. Between the county and CED culverts, there is a moderately steep run of 5.6 percent for 90 feet. Below the downstream control (gravel bar) downstream of the culvert, the gradient is 1.9 percent for 150 feet, increasing to 4.2 percent for 110 feet before decreasing to 2.1 percent for the remaining 450 feet to a tributary confluence. [*Note: Gradients on right-of way were determined by survey; gradients off right-of-way are based on LIDAR imagery and may not reflect current conditions*.]

Upstream, bankfull width varies from eight to 15 feet , while downstream it ranges from seven to 15 feet. The culverts, which are six feet wide, substantially constrict the channel, and contribute to sediment deposition through entrance losses occurring at the inlets.

Immediately downstream of the CED culvert, the channel makes a 90 degree bend to the left (west) and flows in a channelized section along the right-of-way fence line for approximately 150 feet. This channel modification was probably done to allow for the shortest culvert length across SR 8 when it was originally built; the original channel alignment was likely skewed more to the west.

Channel substrate immediately downstream of the culvert prior to the debris torrent was primarily sub-angular to sub-rounded cobbles and gravel (D_{50} ~ 50-75 mm – visual estimate) comprised primarily of basalt. Substrate gradation became finer a short distance downstream, with a D_{50} (visual estimate) of 15-20 mm. After the debris torrent, the channel was filled with sediment ranging in size from silt to large cobble. Currently, much of the downstream channel is blanketed with as much as two feet of fine sediment, ranging from silt to fine sand. Sediment gradation upstream of the CED and county culverts was not evaluated prior to the debris torrent, but was filled with the same type and gradation of sediment as below the CED culvert.

Channel banks immediately upstream and downstream of the CED and county culverts appeared to be in good condition prior to the debris torrent, with grass, shrubs and alder growing nearly continuously to the water line. There was some minor erosion along the outside of the 90 degree bend below the CED culvert. After the torrent, banks upstream of the county culvert were scoured by the hyper-concentrated flows of water, sediment and debris. Downstream of the county culvert, extensive deposits of fine sediment inundated the channel and will be subject to erosion by subsequent flows unless they are excavated and the exposed banks are revegetated.

Site-based factors contributing to the sediment deposition at the CED culvert:

1) Constriction of the channel at the entrances to the county and CED culverts creates substantial hydraulic energy losses, with corresponding losses in sediment transport capacity. The narrower culvert is also more prone to obstruction by sediment and debris.

2) Realignment of the channel below the CED culvert results in a 90 degree bend immediately below the CED culvert. This bend results in additional energy losses and sediment deposition immediately below the culvert outlet.

3) Both the county and CED culverts occur at/below gradient breaks (higher to lower), where sediment deposition would normally be expected to occur. The culverts are too small to accommodate this deposition and, in fact, exacerbate it through factors (1) and (2) above.

Reach Assessment

This reach assessment focuses on the Kennedy Creek watershed from the headwaters in Capitol Forest to the tributary confluence approximately 750 feet below the CED culvert.

Watershed Conditions and Land Cover

The Kennedy Creek watershed above the CED site has an area of 0.79 mi^2 (505 acres). The watershed drains a portion of the north slope of the Black Hills, which is characterized by steep, well-dissected slopes, fairly sharp ridge tops, and creeks that are confined to moderately tight draws (Zurenko, 1995). Elevations range from 490 feet at the lower terminus of the assessment reach to 2355 feet at the summit of Rock Candy Mountain.

Below the CED site, Kennedy Creek flows west to northwest, joining with several minor tributaries, including the creek which drains Summit Lake. It then turns east, incising through bedrock to form Kennedy Falls about eight miles below the site, before turning northeast for three miles to its terminus at Oyster Bay, an inlet of Puget Sound between Shelton and Olympia.

Land cover above the CED site is a mix of conifer and deciduous forest, with approximately 40 percent of the watershed in young (< 30 years) stands. Below the CED site land cover is a mix of pasture, wetland, and riparian forest.

Geology and Soils

The upper Kennedy Creek watershed is underlain by the Crescent Formation, a complex of submarine volcanic and marine sedimentary rocks, including massive to columnar basalt and fine-grained feldspathic volcaniclastic rocks (Logan 1987).

At least two episodes of glaciation affected the watershed. During the earlier (Pre-Vashon) glaciation, the ice sheet terminated on the north slope of the Black Hills, and is responsible for emplacing the band of till soils near the summit of Rock Candy Mountain. The later (Vashon) glaciation advanced to the base of the watershed (up to 750 feet elevation), creating the till soils at the base of the watershed. In between bands of till are non-glacial (residual) soils derived from basaltic colluvium. Large quantities of outwash (well-sorted sands and gravels) and lacustrine deposits fill the valley at and below the CED site. Soils in this area are primarily alluvial (Logan, 1987).

The Kennedy Creek watershed analysis (Zurenko, 1995) identifies the moderate to steep slopes adjacent to creeks and headwall areas as having a high mass wasting hazard, both for natural conditions and associated with timber harvest and forest road drainage. Several small landslides, slumps, and earth flows were identified within the watershed and adjacent basins. Some of these features are recent (within the past 50 years), and some may be thousands of years old.

Hydrology

The upper Kennedy Creek watershed receives an average of 60 inches of annual precipitation, mostly as rain. Till soils in this watershed are moderately well drained in the upper three to four feet. Below this depth a cemented hardpan directs the water laterally until it intersects the surface, either in a channel, or at a spring/seep. Areas with these soils tend to have rapid hydrologic responses once the upper layer is saturated. The soils derived from basalt colluvium tend to be moderately to well drained and provide a less rapid response. These soils also provide more storage to sustain summer flows.

There was a USGS stream gage in lower Kennedy Creek (USGS ID 12078400), but its short period of record (1960-1971) and location downstream of the Summit Lake tributary make it a poor candidate to represent flow condition for the assessment reach. USGS regression equations (Sumioka et al., 1998) were used to derive peak flow estimates at the CED culvert site (Table 1).

Stream Geomorphology and Sediment Transport

Above the CED site, channel gradient increases from moderate (two percent to four percent) to moderately steep (four percent to eight percent) to steep (eight percent to 20 percent). Channel types (Montgomery and Buffington, 1997) corresponding to these gradient classes are plane bed and forced pool-riffle for moderate gradient, step pool and cascade for moderately steep gradient, and cascade, bedrock, or colluvial for steep gradient. Below the CED site, the channel type varies between forced pool-riffle (where LWD is present) and plane bed (where LWD is absent).

It should be noted that these channel types represent a quasi-equilibrium condition. In the event of a major disturbance (such as the December 2007 debris torrent), the morphology in the torrent track becomes greatly simplified. Over time (years to decades), the channel will transition toward these types as sediments and woody debris are sorted and transported and bank vegetation is reestablished. In the meantime, large quantities of sediment delivered to and stored in the active channel will continue to be transported downstream at higher than average rates. At and below the CED site, the channel is currently inundated with fine sediment delivered by the debris torrent, and has shifted its alignment or split into multiple channels in several locations.

Riparian Conditions

Upstream of the CED culvert, riparian conditions vary from “poor” in the short, open reach extending approximately 350 feet above the culvert inlet to “good” in the alder-dominated riparian area further upstream, to “excellent” in the conifer-dominated stands further upstream. The quality of the riparian areas has been diminished somewhat due to the debris torrent, but is expected to recover relatively quickly.

Riparian conditions below the CED culvert vary from “fair” to “poor.” Immediately downstream of the culvert, woody cover (trees and shrubs) is sparse, but cover increases downstream where the creek enters an alder stand.

Large Woody Debris

In-channel LWD is assumed to have been substantially reduced above the CED site by the debris torrent, as a large quantity was deposited at the county culvert and on and along SR 8. Some in-channel debris jams were observed at and above an obliterated road crossing further upstream in Capitol Forest, and bank scour observed at several locations along the torrent track indicates a

potential for increased LWD recruitment as streamside trees are undermined and fall into the channel.

Fish Utilization and Habitat Availability

Kennedy Falls, located approximately eight miles below the assessment reach, serves as a natural barrier to anadromous fish. Cutthroat trout are known to occur in the assessment reach, and rainbow trout have been found downstream and may be expected to utilize the reach. WDFW survey crews identified approximately 1000 feet of good-to-excellent habitat for resident trout upstream of the CED culvert. Habitat quality has been diminished substantially by the debris torrent, especially between the CED culvert outlet and the tributary confluence downstream. Habitat impacts include channel scour upstream and pool infilling with fine sediment downstream.

Reach-based factors contributing to the sediment deposition at the CED culvert:

- High to extremely high rates of sediment transport to the CED culvert due to mass wasting (debris torrent) in the watershed above the CED site.

Evaluation of Treatment Alternatives

Three treatment alternatives were identified which would be expected to address one or more of the site-based factors identified above (see Figure 6). None of the alternatives proposed will address the identified reach-based factor (high sediment supply), which is out of WSDOT control. However, the alternatives should be able to accommodate the excess sediment to some degree. In developing the alternatives below, it is assumed that the county culvert remains in place.

Treatment Alternative 1: Replace Culvert / Maintain Horizontal Alignment

This treatment alternative would replace the existing culvert with a larger concrete box or Con-Span-type structure at the same alignment and gradient (2.3 percent). The new culvert width will meet the stream simulation width requirement (at this site, approximately 20 feet). Because of the slope break (5.6 percent to 2.3 percent) at the entrance, a stable channel bed will be required, which may optionally transition into an "equilibrium" (i.e. transportable) bed downstream. The elevation of the channel bed in the culvert will correspond to the current level of deposition in the existing culvert. This will necessitate raising the roadway a minimum of four feet.

Concerns: This will not eliminate the 90 degree bend below the culvert, and will probably not fully resolve the sediment deposition problem

Treatment Alternative 2: Replace Culvert / Maintain Horizontal Alignment / Realign Downstream Channel

This treatment alternative would replace the culvert as described in Treatment Alternative 1 and eliminate the 90 degree bend by constructing a new channel through the pasture to the north of the right-of-way, connecting to the downstream tributary at (or upstream from) the existing tributary junction. The existing channel from the bend to the existing tributary junction downstream would be abandoned.

Concerns: This alternative will require substantial acquisition of new right-of-way, if the landowner is willing to sell. Alternatives to outright acquisition may make this a more attractive alternative.

Treatment Alternative 3: Replace Culvert/Modify Horizontal Alignment

This treatment alternative would replace the existing culvert with a larger concrete box or Con-Span-type structure, skewing the alignment 30-35 degrees west relative to the existing alignment. Culvert length is estimated to be 160 - 200 feet, and culvert gradient is approximately two percent. The new culvert width will meet the stream simulation width requirement (at this site, approximately 20 feet). The elevation and gradation of the channel bed in the culvert will be based on the result of hydraulic analysis (i.e. HEC-RAS modeling); it is expected that the roadway will need to be raised a minimum of four feet. Below the realigned culvert, approximately 100-150 feet of new channel will be constructed, and the existing channel between the culvert outlet and the new channel will be abandoned. Some minor acquisition of right-of-way may be required, depending on the final alignment and design of the channel. *This alternative is recommended, because it addresses all of the site-based factors and does not require substantial acquisition of new right-of-way.*

References

Logan, R.L. 1987. *Geologic map of the south half of the Shelton and the south half of the Copalis Beach quadrangles, Washington*. Washington Department of Natural Resources, Division of Geology and Earth Resources. Geologic Map GM-34. 28 pp & 2 plates.

Montgomery, D. R., and Buffington, J. M. 1993. *Channel classification, prediction of channel response, and assessment of channel condition*. Washington State Department of Natural Resources Report TFW-SH10-93-002, 84 p.

Sumioka, S.S., D.L. Kresch, and K.D. Kasnick. 1998. *Magnitude and Frequency of Floods in Washington*. USGS Water Resources Investigation Report 97-4277. Tacoma, Washington. 91 pp.

Zurenko, S. E. 1995. *Kennedy Creek Watershed Analysis: Appendix A – Mass Wasting Assessment*. Washington Department of Natural Resources, Forest Practices Division. 100 pp.

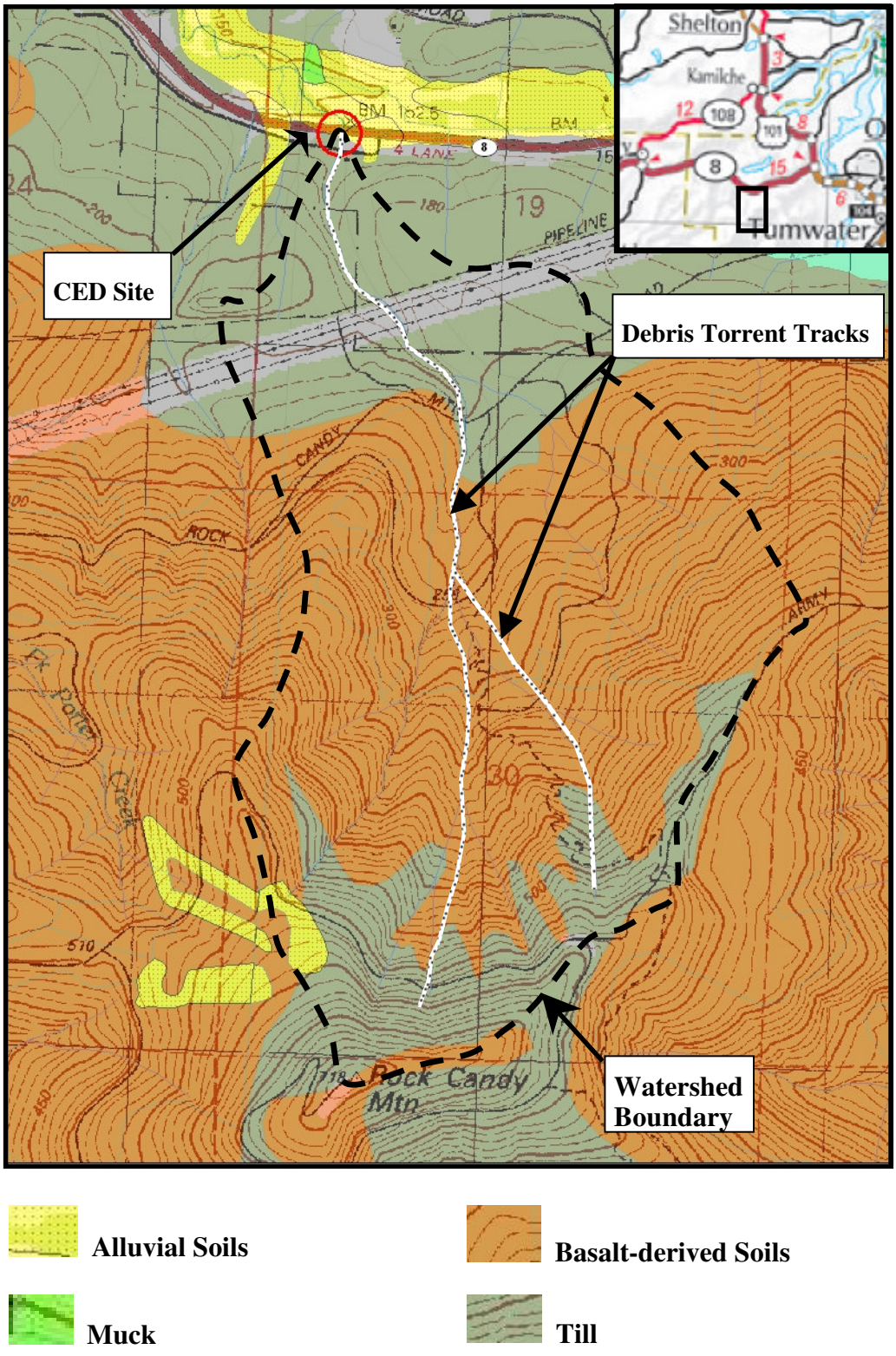

Figure 1. Location of CED site.

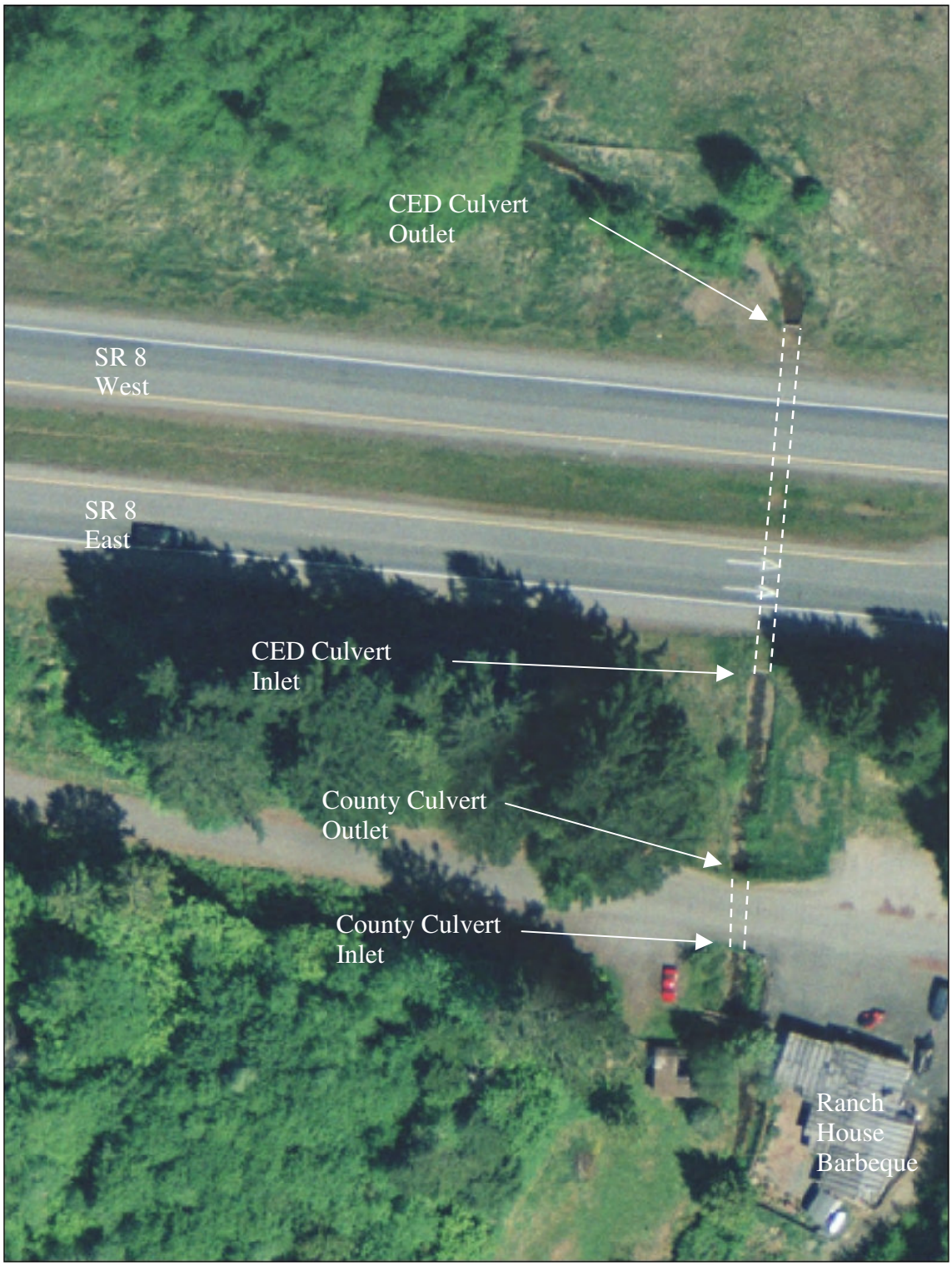

Figure 2. Aerial view of CED site (2006 Thurston County high resolution orthophoto).

< Culvert Outlet (Summer 2006)

Culvert Outlet (12/3/2006) >

< Channel downstream of culvert (Summer 2006)

Channel downstream of culvert > (12/3/2006)

Figure 3. SR 8 MP 15.33 Culvert Photos.

< Debris torrent track approximately 0.6 mi above CED site

Sediment deposition between CED > culvert (in background) and county culvert

< Runout of debris onto westbound SR 8

Debris accumulation behind county > culvert and damage to Ranch House Barbeque restaurant

Figure 4. Debris torrent above SR 8 MP 15.33 site.

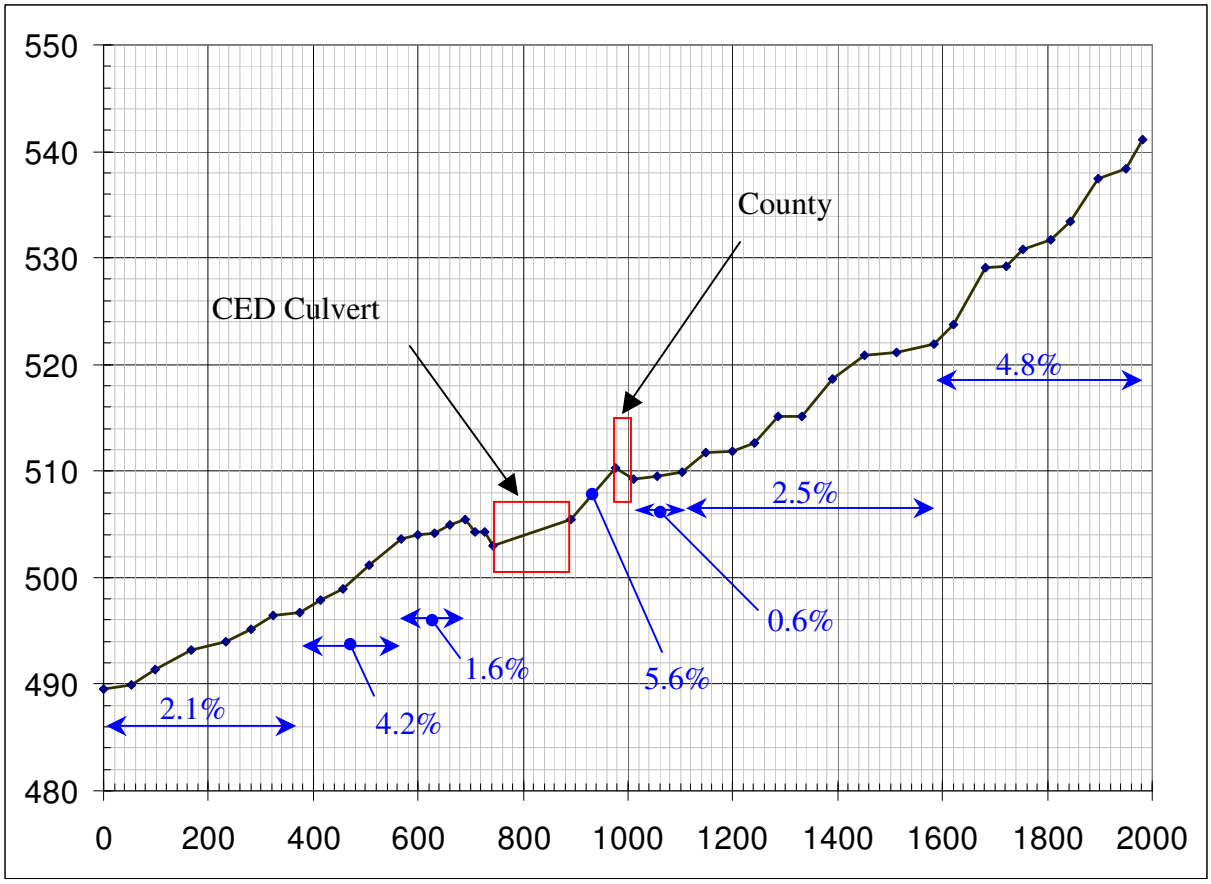

Figure 5. Streambed Profile.

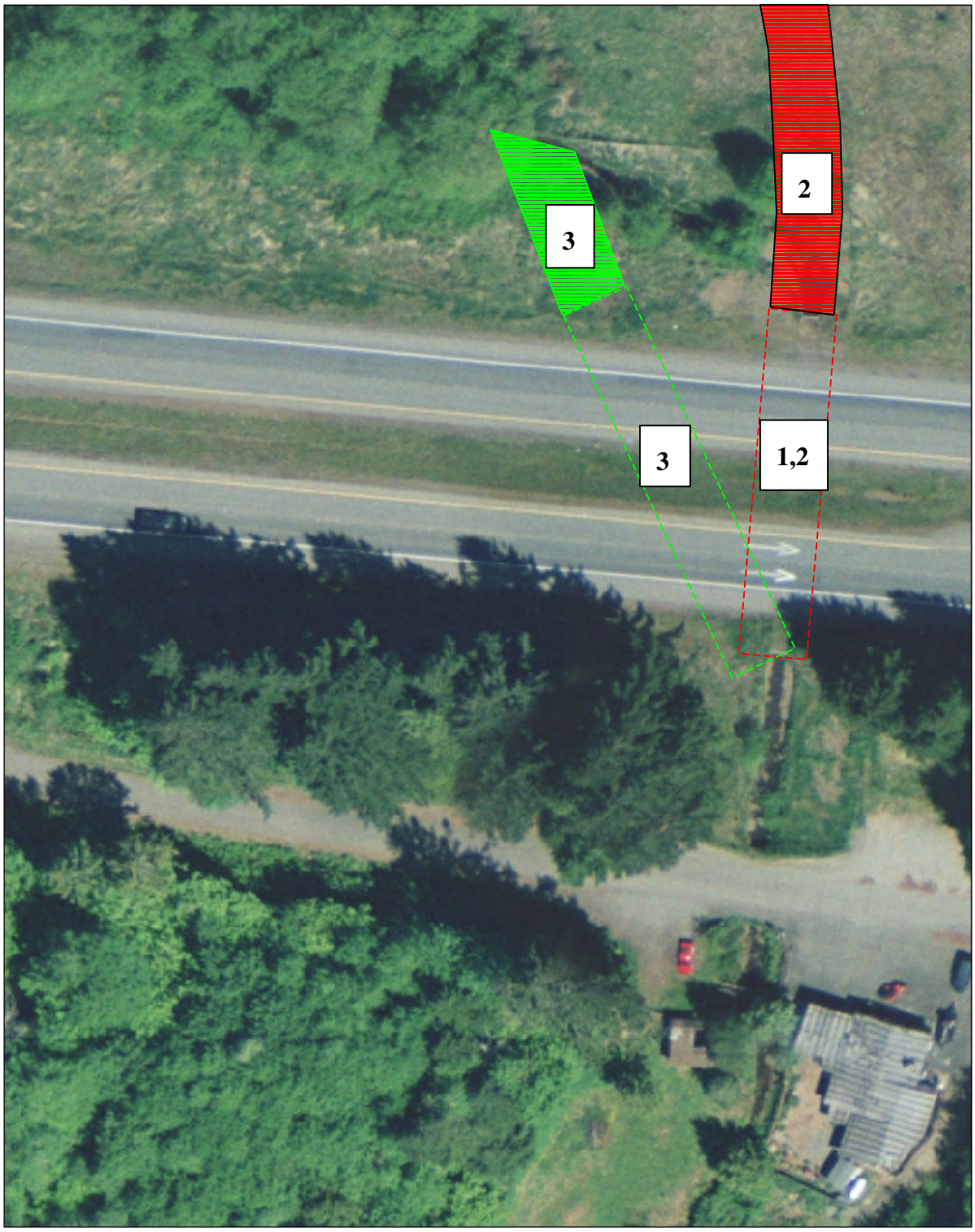

Figure 6. Treatment alternatives for SR 8 MP 15.33 CED site.

Table 1. Peak flow statistics for Kennedy Creek at SR 8.

Recurrence Interval	**Peak flow estimated by USGS regression equation (cubic feet per second)**
2-year	36
10-year	66
25-year	81
50-year	96
100-year	108